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The scale of the problem: understanding the demand for medicinal pangolin products in China

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Abstract

Wildlife conservationists are increasingly concerned about Traditional Chinese Medicine (TCM) due to the demands it places on many threatened species. In particular, pangolin populations in both Asia and Africa have experienced drastic declines driven by illegal trade. However, few studies have attempted to determine the level of this demand for traded species. In this study, we use social science approaches to investigate the pangolin scale trade within China, based upon interviews with informants from hospitals and pharmaceutical shops in two Chinese provinces (Henan and Hainan). Doctors from 41 hospitals and shop owners or shop assistants from 134 pharmaceutical shops were interviewed between October 2016 and April 2017. We show that pangolin scales are under heavy demand and products are available in 34% of the shops and 66% of the hospitals included in this study. Sale quantities were found to vary substantially amongst sellers and no significant factors were found to correlate with sale quantity. Moreover, quantities of products traded by permitted legal sellers are estimated to greatly exceed the supply capacity of legal sources. There is an urgent need to reduce demand from TCM on pangolin scales and revise the current legal pangolin scale trade system. We also highlight the importance of incorporating the TCM sector into combating illegal wildlife trade and species conservation beyond pangolins.

Keywords

animal-based medicine, conservation, demand reduction, market survey, social science, Traditional Chinese Medicine (TCM), wildlife trade

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Introduction

China plays an important role in regulating legal wildlife trade and combating illegal wildlife trade for global biodiversity conservation and further research is required to understand the sustainability of demand and trade in wildlife products within the country (Esmail et al. 2020). In particular, frequent seizures of large quantities of pangolin products have attracted the attention of conservationists worldwide. All eight pangolin species (family Manidae), which occur in Asia and Africa, are threatened with extinction due to illegal trade and threats from trade are not a recent phenomenon. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has listed most pangolin species on its appendices under regulation since 1975, the year the convention came into effect. A stricter zero-trade quota was applied to the four Asian pangolin species in 2000 to further reduce pressures from trade (CITES 2000). In 2016, all eight pangolin species were uplisted to CITES Appendix I, banning all wild-sourced commercial trade (CITES 2016). However, this legislation has not been able to prevent ongoing trafficking in pangolin products (Cheng et al. 2017; Heinrich et al. 2017; Challender et al. 2020).

Pangolin products in trade can be broadly grouped into three types: foods, medicines and ornaments (Challender et al. 2014; Heinrich et al. 2017). Confiscation reports show that each product type is supplied through different trading chains and sold in different end-markets. The current trade of pangolin products is truly international, with over 70 countries across four continents identified as being involved in the trade in various ways (Heinrich et al. 2017). Amongst these countries, China is under the spotlight as one of the main demand markets. All three types of pangolin products are traded in China, with meat and medicinal products reported most frequently (Yang et al. 2007; Xu et al. 2016). Traded medicinal pangolin products are commonly associated with Traditional Chinese Medicine (TCM) (Yin et al. 2015).

TCM has been developed and used in China for many centuries and is still widely practised today (Chow and Liu 2013). In 2016, TCM hospitals and clinics treated 962 million patients, while medical services using TCM treatment accounted for 15.8% of all medical services provided in China (National Health and Family Planning Commission of the PRC 2017). The use of Chinese pangolin (*Manis pentadactyla*) scales in TCM can be traced back to AD 480 in a medical text entitled "*Bencaojing jizhu*", which was later cited in the "Compendium of Materia Medica" (Li 1578). Chinese TCM practitioners generally approve the perceived medicinal value of pangolin scales and use them in prescriptions targeting a wide range of symptoms or illnesses (Wang et al. 2020). Although pangolin scales have recently been removed from the "Pharmacopoeia of the People's Republic of China", some patented medicines or 'zhongchengyao' in the Pharmacopoeia still contain pangolin scales as an ingredient (National Pharmacopoeia Committee 2020).

The Chinese pangolin has been listed as a Second-Class Protected Animal in China and protected under the Law on the Protection of Wildlife since 1989 (SFA of China

1989). It was uplisted to First-Class protection in 2020, with an aim to provide more deterrence and resources for combating illegal trade (SFGA of China 2020). However, the Chinese government still permits a pangolin scale market to operate nationally for medicinal usage, with specific requirements on sources of supply, manufacturers, sellers, annual quotas allowed for sale and a product labelling system (Wang et al. 2022). Market requirements were released by China's State Forestry Administration (SFA, now State Forestry and Grassland Administration) and came into effect in 2008. These requirements specify 711 hospitals in China that are allowed to sell medicines containing pangolin scales (e.g. patent drugs or 'zhongchengyao') and pangolin scale medicines (individual ingredients to be used in prescriptions) (SFA of China 2007, 2008a). All manufacturers and traders are required to hold corresponding permits. There are 209 certified manufacturers in China, which are allowed to produce over 60 types of medicines containing pangolin scales (Xu et al. 2016). All pangolin scale medicines must carry certificates on the smallest packages, to differentiate clearly between legal and illegal products in end-consumer markets. Therefore, illegal trade or illegal products can be identified if: (1) trade participants, such as manufacturers or hospitals, do not hold corresponding permits and/or (2) traded products do not have certificates on the smallest packages.

Trade volume in China is regulated through an annual quota, which has a mean of 26.58 $\pm$ 1.58 tonnes, based on released data from 2008 to 2014 (range; 25.09–29.23 tonnes; SFA of China (2008b, 2009, 2010, 2011, 2012, 2013, 2014)). The detailed policy process that determines the annual quota amount is unclear (Wang et al. 2022) and these regulations also do not specify that scales should be from Chinese pangolins. The source of the legal quota is stockpiles held by individuals or companies, which could contain legal imports of pangolin scales from Africa or other parts of Asia when it was allowed. Seized pangolin products may also be auctioned to permitted buyers without species-level identification to supply the legal market. TCM demand for pangolin products within China therefore poses potential impacts on all pangolin species.

As China constitutes one of the largest demand markets for pangolin products, it is essential to understand the nature of TCM-related demand in order to provide information for management options. This approach is also important beyond pangolin conservation, as other threatened species are involved in the TCM trade in other contexts (e.g. saiga horn, bear bile; Doughty et al. (2019), Wang et al. (2022)). Key questions about pangolin trade in China include the trade volume, the level of demand from the legal market and whether the legal supply is the main source for traded products. These questions are difficult to answer, as the geographic scale over which trade takes place is vast and illegal trade is a sensitive topic to investigate. This study aims to provide preliminary answers to these questions using data from two Chinese provinces. Since our data were collected before the COVID-19 outbreak, our study also provides a baseline for understanding the pangolin scale trade from a quantitative perspective prior to the impact of the pandemic on the use of wildlife products in China.

Methods

Study area

The lead author conducted face-to-face semi-structured interviews in Mandarin between October 2016 and April 2017 across eight Chinese administrative regions in two provinces, Henan (Kaifeng and Zhengzhou Municipalities) and Hainan (Baisha, Haikou, Ledong, Qiongzhong, Sanya and Wuzhishan Counties) (Fig. 1). Chinese pangolin (*M. pentadactyla*) historically occurred in both provinces (Zhang 1997). The current status of the species across China is unclear; it has likely been extirpated from Henan, whereas Hainan still supports a highly-threatened remnant population (Nash et al. 2016).

These study regions were chosen for several reasons. First, we had readily available local networks in both regions that could help us gain access to respondents. Second, Henan and Hainan differ greatly in terms of geographic location, local ecology and biodiversity, culture, economy and human population (National Bureau of Statistics 2020). Henan has a high human population density and a long history of TCM utilisation. In contrast, Hainan is less economically developed and is culturally distinct; local Li and Miao ethnic groups do not have a history of using pangolin scales for medicine and consumption of pangolin products is a recently developed behaviour (Wang et al. 2021). These regional variations provide increased site diversity, with the potential to indicate more general patterns of pangolin product usage across other areas of China that were not logistically feasible to cover in this study. The resulting dataset also allowed us to statistically investigate determinants of geographic variation in patterns of pangolin scale trade.

Interviews

Interviews were carried out in a semi-structured and discursive manner and included questions about annual sales of pangolin scale products and other trade-related information (Suppl. material 1). Some respondents did not answer all questions, either because they did not know the answers or were not willing to provide answers. Questions were not read directly from a questionnaire, but instead were asked in a more nuanced way according to the context of the specific interview conversation to gain more trust and connection with respondents.

Before each interview, we explained the aim of the study, how data would be used and other relevant information. All respondents remained anonymous and provided informed oral consent for participating. We did not ask direct questions about the legality of types of trade behaviour or medicinal products, but instead addressed these topics indirectly, for example, through questions about respondents' knowledge of pangolin trade-related regulations. Illegal trade was further assessed by checking whether hospitals were certified and by looking for trade certificates on products where these were available for examination. Interview methods and questions were piloted before the main study in five pharmaceutical shops in the town centre of Longlou, Hainan; no changes were subsequently made to the study protocols.

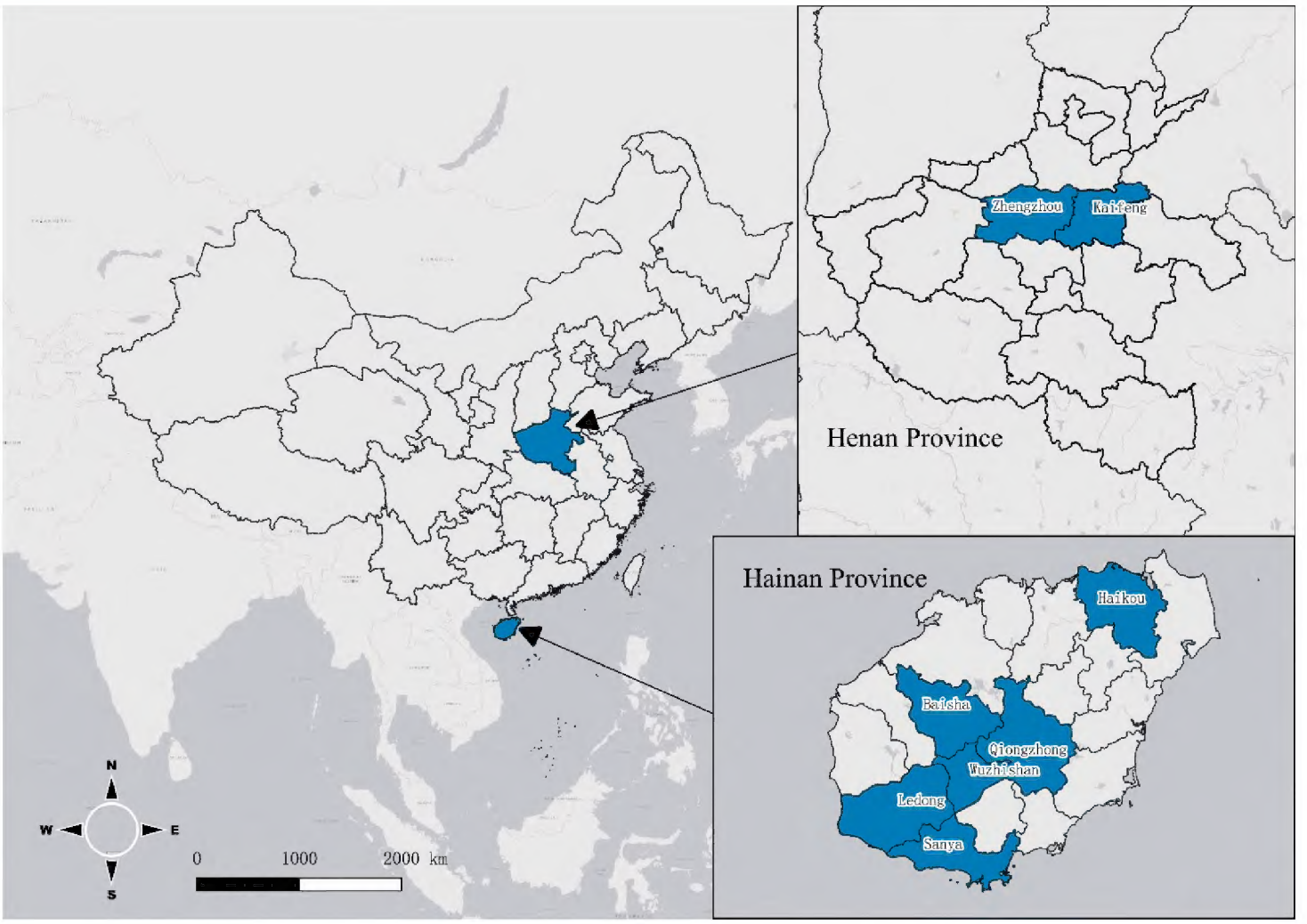

Figure 1. Map showing study sites in Henan and Hainan Provinces. The two provinces are highlighted in the background map and study municipalities/counties are highlighted in the two province-level inset maps.

Respondents in this study included doctors from hospitals (either TCM hospitals or hospitals containing TCM departments) and shop owners or assistants from TCM shops. One respondent per hospital/shop was interviewed, but respondents sometimes asked other people within their establishment for further information about specific questions. We accessed TCM shops in Henan and doctors in Henan and Hainan through social connections (primarily through introductions to potential respondents by friends or family members); therefore, these respondents could not be specifically selected. All hospitals where interviews were conducted had TCM departments or sold TCM medicines. No target sample size was set for hospitals or Henan shop surveys; instead, we aimed to interview as many respondents as possible in the time available. A relatively low sample size was thus expected and unavoidable due to limited access to potential respondents. We located pharmaceutical shops in Hainan through cluster sampling, which involved using an online map (https://map.baidu.com/) to identify areas within each county town/city centre where pharmaceutical shops were centralised. We then conducted interviews in all shops in those areas. Respondents from shops were approached, based on their availability at that moment and their willingness to participate. We sampled a maximum of 30 shops for cities in Hainan where many pharmaceutical shops were located and surveyed all shops in smaller counties that had fewer than 30 shops.

We investigated three main types of pangolin scale products: raw scales, roasted scales (scales treated using standardised TCM procedures, including 'paoshanjia' and

'cushanjia') and scale powder (fine powder produced by blending and sieving roasted scales). Some patent drugs also contain pangolin scales as ingredients, but these medicines were not included in this study as the quantity of pangolin scales they contain was difficult to estimate. Therefore, only three types of pangolin scale medicines were considered, rather than all medicines containing pangolin scales. To calculate the total quantity of scales being traded, we used numerical conversions between these three types of products following Hu and Li (2007), who specified that weight loss of raw scales after the traditional processing method was 20–25%. The size and weight of one scale differs considerably across different pangolin species, animals of different ages and different parts of the body. Therefore, we used the lower boundary of this range (20%) to provide a conservative estimate of the final quantity and assumed 1 kg of raw scales would produce 0.8 kg of roasted scales. We also assumed 1 kg of raw scales would produce 0.53 kg of scale powder through the process of blending and sieving roasted scales, based upon information obtained from two TCM practitioners who independently reported the percentage loss as around one-third due to sieving; this ratio is supported by written descriptions on packages of pangolin scale powder medicine observed during our study, which stated "1.4 g of powder = 6 g of roasted scales". We again used the lower boundary of these estimations (33.3%) as a conservative ratio. Reported quantities were all converted to roasted scales for data processing.

Analytical methods

Generalised linear models (GLMs) were used to investigate potential relationships between annual sale quantities of pangolin scale products (normally distributed response variable) and potential predictor variables (see Table 1). We assumed that product price, local human population size, local economic development, hospital size and pharmaceutical shop type (chain shop versus private shop) might all potentially influence the annual sales quantity: we expected that product price and private shops might be negatively correlated with higher sales, whereas other predictors might be positively correlated. Separate analyses were conducted for results from hospitals and shops. All predictors were first included in maximal models and stepwise selection (R function *stepAIC*) was then used to find the best-performing models with the lowest Akaike Information Criterion corrected for small sample size (AICc). Additional GLMs were conducted to investigate which variables could predict whether hospitals or shops reported selling pangolin scale products (binary response variable). One-sample t-tests were also conducted to compare means of sales between years. All statistical analyses were performed using R version 3.5.2 (RStudio Team 2015). Study methods were reviewed and approved by the Department of Geography Ethics Review Group, University of Cambridge (#1503).

Results

We interviewed doctors or sellers from 41 hospitals and 134 pharmaceutical shops in eight municipalities/counties. Pangolin scale products were sometimes on display and

Table 1. Predictors included in GLMs investigating sale of pangolin scale products in hospitals and pharmaceutical shops, with variable type specified. "3A-grade" refers to the Chinese system for evaluating hospitals (3A is the highest grade).

Predictors	In both models	In hospital model	In shop model
Mean sale price	Continuous		
Municipality/county	Categorical		
Municipality/county population	Continuous		
Municipality/county GDP	Continuous		
Province	Categorical		
TCM-specialized hospital		Binary	
3A-grade hospital		Binary	
Chain-shop or private-owned			Binary

we observed both legal and illegal products being sold (i.e. products with and without trade certificates) by both legal and illegal sellers (i.e. certified hospitals and non-certified hospitals and all pharmaceutical shops). Hospitals with legal trading permits were also found selling products without the legally required certificates, while legal products were also found in uncertified hospitals.

Hospital results

A high proportion of interviewed hospitals sold pangolin products, with sales quantities of considerable size. Of the 41 hospitals, 27 (65.9%) were found to sell pangolin scale products and 20 reported data on sales quantity. In total, these 20 hospitals sold 1905.8 kg roasted scale (2382.3 kg raw scale) in one year, with a mean of 95.3 $\pm$ 193.9 kg per hospital per year. Eight of the 27 hospitals that sold pangolin scale products held a legal permit. Seven of these eight permitted hospitals reported sales data; in total, these seven hospitals had sold 423.0 kg of roasted scales during the previous year, equivalent to 528.8 kg of raw scales. In addition, 13 of the 19 unpermitted hospitals that sold pangolin scale products also provided sales quantity data; in total, these 13 hospitals had sold 1482.9 kg of processed scale products during the previous year, with a mean of 114.1 $\pm$ 226.5 kg per hospital per year, equivalent to 1853.6 kg of raw scales.

Reported annual sales also varied considerably across hospitals (Fig. 2). Ten hospitals reported selling less than 20 kg per year, while four hospitals reported annual sales quantities of over 200 kg of roasted scales; three of these four hospitals did not hold trade permits. The four hospitals with the highest annual sales quantities were all located in Henan. Sales quantity was not explained by any predictor variables included in GLMs ($P > 0.1$ or NA, $N_{hospital} = 19$), including price (Fig. 2). Hospitals in cities with larger populations were more likely to report selling scale products ($P = 0.03$, $N_{hospital} = 41$).

Two hospitals in Zhengzhou also provided longer-term sales data on the total amounts of roasted scales purchased each year from 2012 to 2016, in addition to sales data for 2017 (Fig. 3). Both hospitals purchased pangolin scale medicines multiple

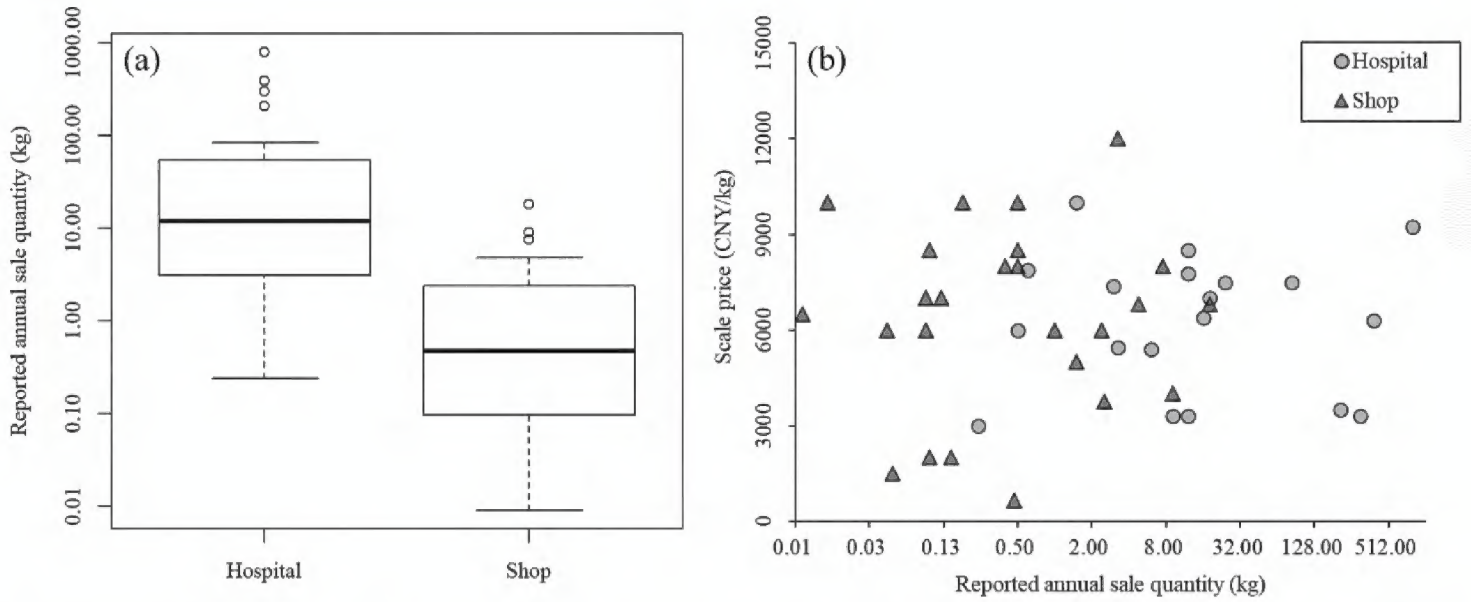

Figure 2. a Box plot showing reported sales quantities in hospitals and shops ($N_{hospital} = 20$, $N_{shop} = 25$) **b** scatter plot showing sale quantities and corresponding prices reported by hospitals (circles) and shops (triangles) ($N_{hospital} = 19$, $N_{shop} = 25$).

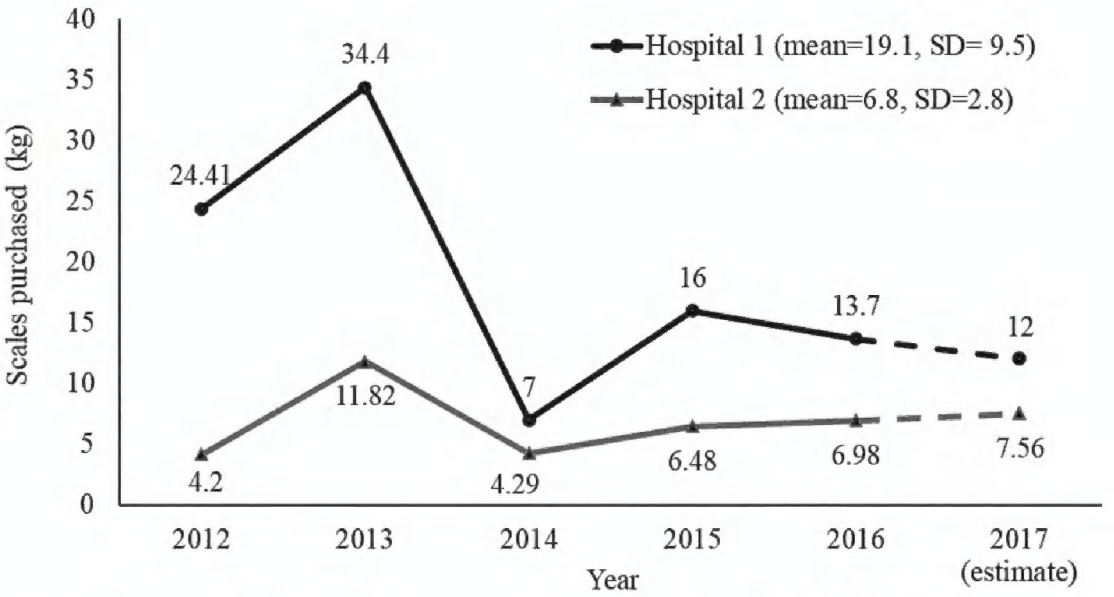

Figure 3. Reported volumes of roasted pangolin scales purchased by two hospitals in Zhengzhou, Henan Province, from 2012 to 2016.

times per year depending on demand, so that purchase quantities indicate annual sale quantities. For both hospitals, the mean of sales across the previous five-year period did not differ statistically from sales data estimated for 2017, based on sales during the first four months of 2017 (one-sample t-test, $P_{hospital\ 1} = 0.208$; $P_{hospital\ 2} = 0.998$), indicating that sales data for 2017 are representative of the general market situation.

Shop results

Over a third (n = 46, 34.3%) of the 134 surveyed pharmaceutical shops reported selling pangolin scale products. Sales quantity again varied substantially across shops (Fig. 2). A total of 25 shops reported sales quantity data. These shops sold a total of 53.3 kg of processed scales in one year (66.6 kg of raw scales), with a mean of 2.1 $\pm$ 4.0 kg per shop per year. Reported sales quantity again varied greatly amongst shops, with most

shops reporting very low sales quantities and a few shops reporting high sales quantities. Sales quantity was not explained by any predictor variables included in GLMs ($P > 0.1$ or NA, $N_{shop} = 25$), including price (Fig. 2). Chain shops were more likely to report sales compared to private shops ($P = 0.003$, $N = 134$).

A total of 11 shop respondents provided information on variation in demand for pangolin scales over the previous few years. Eight of these 11 respondents said that demand was stable because TCM products were typically purchased by relatively wealthy consumers, whereas the remaining three respondents said that demand fluctuated with price. Two respondents (one hospital respondent and one shop respondent) provided information on seasonal variation in demand; both respondents considered that TCM sales in general were lower during summer months, because TCM "tasted bad" (referring to the bitter taste of most TCM products) and people did not like to take it when their appetite was already reduced due to hot weather.

Discussion

Our study reveals that pangolin scale products were widely available in hospitals and pharmaceutical shops across Henan and Hainan Provinces during the time of our survey. At a policy level, government regulations specify that only 711 listed hospitals in China are legally allowed to sell pangolin scale products directly to consumers (SFA of China 2007, 2008a). However, we found that 46% of surveyed hospitals and 34% of surveyed pharmaceutical shops were selling pangolin scale products illegally. Some legal sellers (i.e. permitted hospitals) were also observed selling illegal pangolin scale products, as evidenced by the absence of trade certificates on product packages. Our study, therefore, highlights the urgent need for managing legal and illegal pangolin product trade across China.

The presence of illegal pangolin scale products in pharmaceutical shops has been previously reported (Yin et al. 2015; Xu et al. 2016). However, little research has previously been conducted on trade in pangolin products in Chinese hospitals. The co-occurrence of legal and illegal trade makes the trade in hospitals more complex than for other types of sellers. Our results show that many hospitals sell pangolin scale products illegally and annual sales quantities reported by these hospitals are also high and of significant conservation concern. These findings together suggest that illegal products have penetrated the legal pangolin product sale system.

The quantity of pangolin scale products involved in the three types of sales channels varies substantially, both between different groups of sellers and within the same seller group. None of the variables investigated in this study was found to explain the observed variation. Qualitative observations during interviews suggest that this variation might instead be more related to individual doctors' preferences and specialities rather than wider external factors, posing difficulties in estimating accurate provincial-level or national-level trade volumes across China using regional data.

However, it is still meaningful to estimate market size on a larger geographic scale, to provide some understanding of the possible level of medicinal trade in pangolin

products across China. Extrapolating from the sales data that we obtained from permitted hospitals included within our study, we provisionally estimate that annual sales across the 711 permitted hospitals in China could be 53.7 tonnes, twice the mean legal quota of 26.58 tonnes per year. Although we recognise that this extrapolation is only approximate, it suggests that the demand on medicinal pangolin products in China is likely to be high and above legally permitted levels. We also note that our survey did not collect data on sales levels for patent drugs, another group of medicines that can legally contain pangolin scale products and share the annual national quota with prescription medicines. As our estimates are based only on data for prescription medicines, actual trade volumes of medicinal pangolin products could, therefore, be even higher, further widening the gap between legal supply capacity and market demand.

Our results show that sale of medicinal pangolin products is more likely to be reported by hospitals in cities with higher populations, suggesting a potential greater demand for pangolin products across more heavily urbanised areas of China and, thus, raising further potential concerns about sustainability of levels of demand. Our shop survey results also demonstrated that sale of pangolin products was more likely to be reported by chain shops rather than by private non-chain shops. This finding might indicate either genuine variation in sales between different types of shops or that owners of private non-chain shops know more about the illegal nature of pangolin scale trade and are, thus, less likely to report sales (Wang et al. 2020).

Reducing illegal pangolin trade within China is recognised as a global conservation concern (Wang et al. 2022). Our results thus demonstrate that illegal trade in pharmaceutical shops and uncertified hospitals within China represents a management priority for pangolin conservation. Understanding and reducing consumer demand for pangolin products and collaborating with the TCM sector to encourage the use of substitutes and raise awareness about legislation, are identified as potential mitigation strategies (Luo et al. 2011; Wang et al. 2020). Another proposed option is to increase the supply of medicinal pangolin products through farming. However, although conservation breeding has been carried out for some pangolin species (Parker and Luz 2020; Yan et al. 2021), establishing pangolin farming at a commercial scale is still a long way off, due to numerous well-recognised technical difficulties, such as designing suitable feed (Wicker et al. 2020). The two current problems facing pangolin conservation that we highlight in China, widespread illegal trade and very limited legal supply capacity compared to market demand, instead both need urgent mitigation rather than relying on solutions that are not feasible in the near future. More generally, the effectiveness of farming wildlife to relieve pressure on wild populations requires comprehensive and critical evaluation to ensure that it does not have unforeseen negative consequences, such as increasing demand or providing a cover for laundering of illegal products (e.g. Kirkpatrick and Emerton (2010); Lyons and Natusch (2011); Turvey et al. (2021)). More research is, therefore, needed to understand the complex dynamics of pangolin trade, to ensure that commercial farming would not pose additional threats to wild pangolin populations (Challender et al. 2019; Chen and 't Sas-Rolfes 2021).

Collecting accurate data using social science research methods can be challenging for sensitive topics such as illegal activities. However, illegality of pangolin product trade was not well recognised by most respondents during interviews (Wang et al. 2020), which led to greater willingness to discuss the trade openly. Moreover, we aimed to build trust with respondents by providing maximum anonymity and maintaining a neutral position during interviews (Cunliffe and Alcadipani 2016). All hospital respondents were approached through social network connections, which further helped to establish trust (van Uhm 2016). Respondents were not pushed to answer questions and were free to withdraw at any point during the interview. However, despite these protocols, we consider it more likely that respondents will have under-reported rather than over-reported sales behaviour due to the sensitive nature of the subject and our direct questioning technique (Olmedo et al. 2021). This consideration thus suggests that actual sales levels of medicinal pangolin products might be greater than indicated in our study, raising even further concerns about the sustainability of this trade and its wider impact on wild pangolin populations.

Conclusion

Our study shows that the illegal pangolin scale trade is widespread in China and that pharmaceutical shops and hospitals are both contributors. Legal products were observed in illegal sale channels and hospitals holding legal permits also sold illegal products. The amount of scale products sold by certified hospitals might greatly exceed the legal supply capacity. Our findings, thus, highlight the need to better regulate and rethink the current legal market. More detailed regulations might be needed to ensure a close legal trade framework that will prevent legal products leaking out of allowed trade routes, while preventing the sale of illegal products. Redesign of existing legal market management strategies, combined with large-scale demand-reduction interventions and stronger enforcement of existing regulations, is, therefore, an urgent policy priority in China for both global pangolin conservation and public health concerns.

Although this study only focused on pangolins, our methods and insights are also useful for studying and conserving other threatened species involved in the TCM trade. For example, the saiga horn trade is regulated within a similar legal framework in China, with only certified hospitals allowed to sell products to patients (SFA of China 2007). Conservation issues identified in pangolin trade might, therefore, also be concerns in saiga horn trade and other animal-product trades. This highlights the need for more research on the dynamics and sustainability of TCM trade across different species, with a focus on understanding markets and assessing enforcement effectiveness. We also recognise that this study was conducted before the COVID-19 pandemic, which has had a major impact on wildlife trade management and markets within China. We, therefore, provide a baseline for future studies to investigate markets and trade dynamics before and after COVID-19.

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Supplementary material 1

TCM survey questions

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Data type: questions (word document)

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